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Yield of Concrete

Civil Engineering

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THE YIELD OF CONCRETE


...BY...

William Ashway McCully

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1904



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May 27, 1904 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

WILLIAM ASHWAY McCULLY

ENTITLED THE YIELD OF CONCRETE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Isaac Baker

HEAD OF DEPARTMENT OF

Civil Engineering

A knowledge of the amount of materials required to produce a cubic yard of concrete is of importance in making estimates of cost and in determining the quantity required for any particular job. Since there are but little data on this subject, the writer made a series of experiments to determine the amount of concrete produced from a given quantity of mortar and broken stone. Preliminary to the investigation of the subject mentioned above, several experiments were made to determine the effect on the yield; of measuring the concrete in cylinders of different diameters. In the tests made with 6-inch, 10-inch, and 12-inch cylinders, it was found that the size of the cylinder had practically no effect on the yield.

← WATERHILLS →

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→ MATERIALS. ←

The stone was Kanawha limestone of such a size as passed a 1-inch sieve and was retained in a $\frac{1}{2}$ -inch sieve; and contained 44.3 per cent of voids when rammed. The per cent of voids was determined by letting the stone drop into water and ramming it into place as it fell. This method gives the maximum per cent of voids; as less air is introduced than by other methods. The cements used were Cumberland and Louisville natural. Portland cement would doubtless have given the same result.

The mortar was one part cement (measured loose), and two parts sand (also measured loose), mixed wet. It was found necessary to moisten the stone in order to obtain a perfectly

mured concrete; not only enough water was used to produce a concrete in which water would flush to the surface after vigorous tamping. All measurements were made in a cylindrical tile ten inches in diameter and twenty-five inches long. All tamping was done with a $2\frac{1}{2}$ -inch gas pipe, six feet long, weighing about sixty pounds, having a wooden plug in its lower end and giving a tamping surface of $4\frac{1}{2}$ square inches. In tamping the pipe was dropped about six or eight times.

→ METHOD. ←

The stone was tamped into the tile, and the volume measured. It was then tamped out, and mortar equal to a quarter cent of the volume was added; and the result, a concrete, was tamped into the tile and

in the layers, each layer receiving from four to six times the transpiration, distributed uniformly over the surface. The volume was measured and the per cent. found for the volume of the stone tested. The results of these tests are given in Table I. Each result is the mean of from two to six experiments. Two tests only were made when the results checked closely.

From Table I it is seen that when the volume of the mortar is just equal to that of the voids in the stone, the volume of the broken concrete is .073 times that of the stone. This is due to the fragments of stone becoming coated with a film of mortar which holds them apart, thus

TABLE I.

Increase of Volume by Mixing Mortar with Broken Stone.

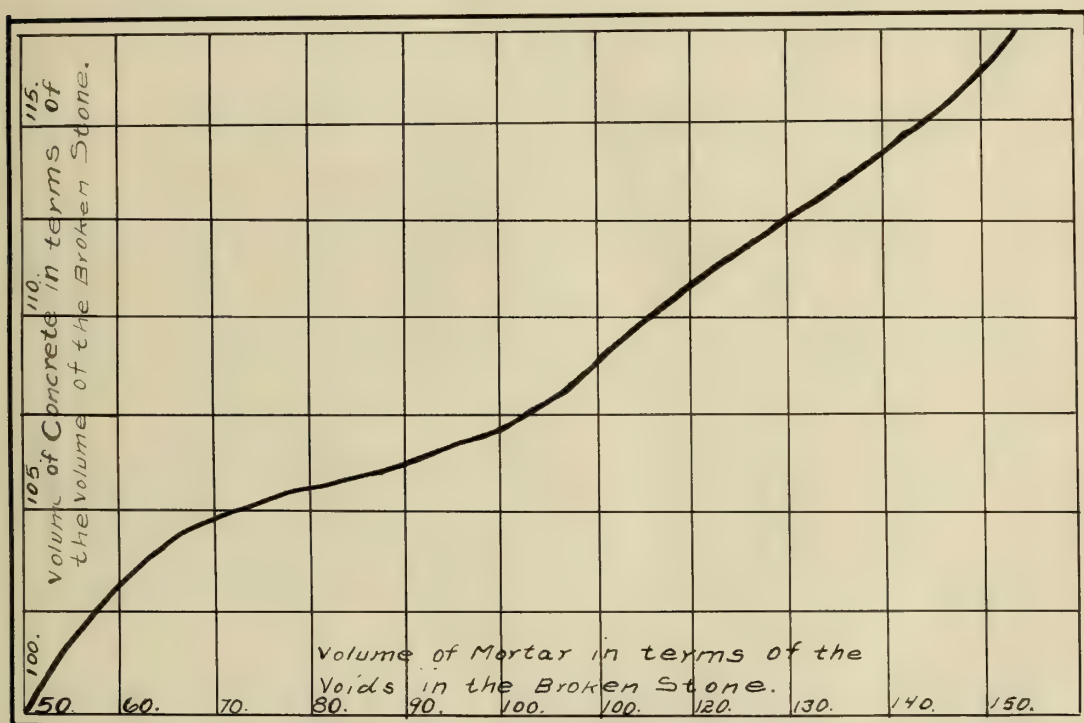
Ref. No.	Volume of Mortar in Terms of the Voids in Broken Stone. Per Cent.	Volume of Concrete in terms of the Volume of Stone. [Both Rammed] Percent	Voids in Rammed Concrete (When wet).
1.	40.	100.0.	26.58.
2.	50.	101.4.	23.22.
3.	60.	102.9.	20.02.
4.	70.	105.0.	17.41.
5.	80.	105.4.	13.55.
6.	90.	106.2.	10.02.
7.	100.	107.3.	6.80.
8.	110.	109.0.	4.19.
9.	120.	110.8.	1.15.
10.	130.	112.7.	0.00.
11.	140.	114.2.	0.00.
12.	150.	116.5.	0.00.

increasing the volume and also the voids of the concrete. It is also seen that mortar is still the voids at

least 130 per cent of mortar must be added; and to secure a volume of concrete just equal to the volume of the stone, not more than 40 per cent of mortar must be added. Fig. 1 is a curve plotted from the results on Table 1. The writer is unable to account for the sudden rise in the curve at the point where the volume of the mortar is equal to 70 per cent of that of the stone; but he is fully convinced that it is not due to an error in the experiments. After having finished the tests and plotted the curve, the writer made several special tests with 70 per cent of mortar,

— Curve Showing. —

Increase of Volume by Mixing Mortar with Broken Stone.



— Figure I. —

and checked the first results very closely.

The heat of concrete varies greatly with the amount of water, and but slightly with the degree of tampering. This fact has been established in the experiments from which the following were deduced, as well as a considerable number of other concrete made particularly to test these conclusions. In the last mentioned experiments different per cents of water were used with constant tampering. A difference of almost 700 percent in the increase was noted between the two extremes; while with a constant per cent of water and different degree of tampering there was but little difference in the increase. With the

same amount of transpiration
 wet concrete will be better
 than dry, is more dense
 and consequently ^{is} stronger
 than dry concrete. In practice where the best
 results are sought and the
 cost of construction can not
 be ignored, it would be ad-
 vantage to use a much
 wetter concrete than other-
 wise. It should be remem-
 bered that the results given
 in Table I were determined
 with a comparatively dry
 concrete, and that the
 volume of concrete may be
 reduced by the use of more
 water and cement. The
 writer found that the increase
 in volume due to the ad-
 dition of mortar to be
 from one-fourth to one-half
 greater when the
 concrete was wet than when

it was used. The concrete most commonly used in practice is about as wet as that used in obtaining the values in Table I.

The results in Table I were very carefully determined, and are thought to be essentially free from error. Larger volumes of concrete were used than in any similar experiments, and the usual care was given to mixing and tamping.

From the values in Table I the writer deduced Table II which gives the quantity of stone and mortar necessary to produce a yard of rammed concrete. The results in Table I are for stone containing 7 per cent of voids when rammed. If the stone has more than 7 per cent of voids, the amount

TABLE II.

Mortar and Broken Stone Required for a
Cubic Yard of Concrete.

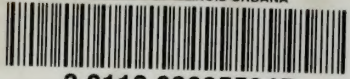
MORTAR.		Broken Stone having 44.3 per cent of Voids, when rammed. Cubic Yards.	Percent of Voids in the Rammed Concrete.
In terms of Voids in the Rammed Stone. [Percent]	Volume req'd in Cubic Yards.		
40.	0.177.	1.00.	26.58.
50.	0.218.	.985.	23.22.
60.	0.257.	.97.	20.02.
70.	0.295.	.952.	17.41.
80.	0.336.	.95.	13.53.
90.	0.374.	.94.	10.02.
100.	0.410.	.93.	6.80.
110.	0.448.	.92.	4.19.
120.	0.480.	.90.	1.15.
130.	0.510.	.89.	0.00.
140.	0.54.	.87.	0.00.
150.	0.57.	.86.	0.00.

required will be the same as that given in the table; but to obtain the quantity of mortar to be used, it is necessary to divide the value given in Table II by 44.3 and multiply the result by the per cent of voids in the stone to be used.





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